Patent Application

Recording System for Vehicles with GPS

Technical Field

The invention relates to a recording system for recording vehicles with a position determining system, for example a satellite navigation system or bearing taking system, when using roads, with the features:

(a) means for permitting a vehicle to transmit its received coordinate signal to the recording system,

(b) the recording system comprising a computer unit;

(c) a digital road map being stored in a memory of the computer unit

(d) selected roads of the road map being subdivided into appropriate sections;

(e) each section, in turn, being subdivided into digital rectangular segments;

(f) means for associating the coordinates of the respective detected vehicle with the rectangular segments,

(g) each section of the rectangular sections having an appropriately selected length of the rectangular segments;

(h) the rectangular segments overlying the course of the road.

Furthermore, the invention relates to a method of recording vehicles with a position determining system, such as satellite navigation system (GPS),, when using roads, with the following steps:

(a) transmitting the received coordinate signal to a recording system with a computer unit, the memory of which has stored therein a digital road map;

(b) subdividing selected roads of the road map into appropriate sections,

(e) subdividing each section, in turn, into digital rectangular segments,

(f) associating the coordinates of the respective detected vehicle with the rectangular segments,

(g) assigning to each section an appropriate length for the rectangular segments;

(h) superimposing the rectangular segments to the course of the road.

Prior Art

In some countries, fees are raised for the use of certain roads such as highways, large bridges or tunnels. Usually, these fees for using roads, also called toll, become due at certain points at toll stations, on highways, as a rule, at the exit. The procedure can be described briefly as follows: A user drives with his vehicle, at first, onto the highway at a highway entrance. There, he pulls a toll card from a toll station, which card indicates, where he has entered the highway. When exiting, the distance covered will be determined at a toll station at the exit, an a corresponding fee is collected.

In other countries, a vignette is sold to transit travellers at the border. Only the holder of such a vignette are allowed to use certain roads as, for example, highways.

Both methods have advantages and disadvantages. Raising toll by way of toll stations requires relatively much staff, as the toll has to be collected at the toll stations by human

man power. The toll is, however, related to the actually covered distance. A further disadvantage of the collection of road using fees by means of toll stations is that, with heavy traffic, the toll stations are the starting points of traffic jams. Though the vignette solution does not require particularly much staff, as the vignette may be sold in any shop, it affects, however, all, also those who use the toll road only for a relatively short time. Such persons pay a very high price for the short-time use.

Another solution for the raising of toll are recording systems through radio, where the accounting can, as a rule, take place later. Such a recording system is known from the European patent 0 730 728. Here, the vehicles to be recorded have an equipment for receiving satellite navigation signals. Thereby, the instantaneous geographic position of the vehicle is determined. The respective coordinates are transmitted by radio to a computer device. A digital image of the road maps in vector representation is stored in the computer device. Some roads thereof are selected as subject to toll. These roads subject to toll are subdivided into individual sections. A plurality of appropriately long and rectangular segments are overlaid to each section, so that the whole respective section is covered. Depending on the course of the road, these segments have different lengths, the lengths of the segments of one section being always identical. In order not to make the number of the rectangular segments too large, the rectangular segments are wider than the road itself. Thereby, also relatively small curvatures are automatically covered, without requiring breakdown of the section into still finer segments. This saves memory capacity and, in the end, also computing time, as not so many data have to be processed as with a very fine segment breakdown. By optimization, the appropriate segment length can be found for each section, such that the required memory capacity in the computer device can be kept low. As soon as the coordinates of a detected vehicle gets into such a segment, the toll falls due and is recorded. As soon as such a segment is left, no further toll will be collected.

This kind of section and segment formation suffers from a serious disadvantage: As soon as a road not subject to toll extends close enough to a road subject to toll, a vehicle on the toll-free road would suddenly get into the toll-ticketing. Therefore, these "critical areas" are, at present, exempt from the toll-ticketing. Thus, a section commences once in front and once behind this "critical area".

Disclosure of the Invention

Therefore, it is an object of the invention, to eliminate the disadvantages of the prior art and to provide a system and a method, in which such "critical areas" are taken into account, when recording a vehicle. At the same time, the used memory capacity is to be optimally utilized.

According to the invention this object is achieved in that, with a recording system for recording vehicles with position determining system of the type mentioned in the beginning,

(i) for each section, a respective appropriately selected width of the rectangular segments is provided.

In addition, the object is achieved by a method of recording vehicles with a position determining system of the type mentioned in the beginning with the following step:

(j) assigning an appropriately selected width for the rectangular segments to each section.

Up to now, the roads which have been relevant for vehicle recording were stored as digital road maps in one or more computers. These digital road maps are provided, in particular, by commercial traders of geographic map material. In order not to have include each individual point of the course of the road into the computer -for reasons of memory capacity- the roads to be taken into account are subdivided in sections. Rectangular sectors or rectangular segments are, in turn, overlaid to these sections. The rectangular segments have always the same size for each respective section. Up to now, they were dimensioned to have always the same width.

The invention is based on the principle to vary also the width of the rectangular segments for each section appropriately. Thereby, these rectangular segments can also be matched with critical areas. In the following, the term "critical areas" is to cover such areas of the

digital road map, where at least two areas are so close together that the area in which a vehicle is not to be recorded falls within the area to be recorded. Two roads stretching closely adjacent each other may form such a critical area, as, for example, a country road stretching immediately parallel to a highway, the highway being an area to be recorded and the country road being no such area. Only the vehicles on the highway are to be recorded. By varying the rectangular segments as to their width, this situation can be taken into account without utilizing much more memory capacity and computing time involved therewith. Nevertheless, the vehicle is recorded over the whole course of the road, while, in the prior art, these critical areas had to be spared for the recording.

It has been found to be a preferable modification of the invention, that the sections have different lengths. In this way, the system becomes very flexible and variable. The sections can be made to have a length that optimal utilization of the computer memory and, thereby, of the computing time involved therewith is ensured. Preferably, in the case of a highway, the sections are selected to extend from exit to exit.

In a preferred embodiment of the recording system of the invention the selected roads are roads subject to toll, such as highways. In this way, the recording system can be used to monitor roads subject to toll. Each vehicle which used the monitored road is recorded by the system of the invention and has to pay the due toll.

When a vehicle enters the recording system, this system has to be activated. To this end, in an appropriate embodiment, means are provided for activating the recording of the vehicle not before the coordinate signal enters a rectangular segment. Analogously, the recording system has to be de-activated again. Preferably this is effected by appropriate means for de-activating the recording of the vehicle upon the coordinate signal leaving a rectangular segment.

In order to enable unambiguous allocation of vehicle and recorded coordinates, a preferred embodiment provides identifying means for transmitting an individual identifying signal (80) to the recording system (84) for unambiguous identification of a recorded vehicle. Thereby, it is established, unambiguously, to whom the recorded coordinates belong and who has to be charged with the fees for using the road.

Furthermore, in a preferred embodiment of the invention, means are provided for determining the entrance and/or exit angle at which a vehicle enters or leaves a rectangular segment. On the basis of the entrance or exit angle, respectively, an additional criterion is obtained, which permits recognition of whether a vehicle is in an area to be recorded or not. For example, in an intersection area, the vehicle usually does not move parallel to a road, if it only crosses this road. Thus this vehicle has a certain entrance or exit angle, respectively, relative to the area to be recorded. If the vehicle gets into the area to be recorded within a predetermined angular interval, this vehicle will be considered by the recording system as a crossing vehicle only.

Furthermore, in a preferred embodiment, there are means for optimizing or reducing, respectively, the data quantities, in particular of the road data, of the section data and of the data of the rectangular segments. These means may, for example comprise appropriate compression algorithms, whereby the data can be kept relatively compact.

In a further advantageous embodiment of the invention, the digital road maps are provided in the form of vector data. This ensures simple processing of the map data in the computer. An optional scale can be assumed for the digital maps without changing the basic information of the vector data and, thus, of the digital map.

Furthermore, means are provided for fixing a tolerance range within which activation and de-activation of the recording of the vehicle takes place. This is to prevent vehicles which must not yet be recorded which, however, reach the edge of the area to be recorded, from being taken into consideration with the recording. Here, it has been found advantageous, if a certain tolerance range for the activation and de-activation is fixed.

It has been found as an advantageous modification of the method of the invention, that an appropriately selected length is assigned to the sections, these length being possibly different. A further aspect of the method of the invention is, that toll roads are selected as relevant roads.

In an appropriate modification of the method, subdivision of the roads in sections is effected, in the case of highways or highway-like roads, from exit to exit. This facilitates the application of the method of the invention.

Preferably, with the method, recording of the vehicle is not activated before the coordinate signal enters a rectangular segmen and is deactivated upon the coordinate signal leaving a rectangular segment. Thereby it can be avoided that the vehicle to be recorded is continuously observed. For the unambiguous allocation of the coordinates to a vehicle, according to a further advantageous modification, an identification signal for unambiguously identifying a recorded vehicle is transmitted to the recording system. As soon as the recorded coordinates are allocated to a vehicle, also the corresponding fees can be allocated to this vehicle.

Preferably, analogously to the recording system of the invention, also with the method of the invention,
the entrance angle and/or the exit angle at which a vehicle enters or leaves, respectively, a rectangular segment is determined.

In a preferred modification of the method, a data optimization or data reduction, respectively, in particular of the road data, the section data and the data of the rectangular segments takes place. This optimization can be effected by appropriate arrangement and the reduction of the data by data compression with compression algorithms.

Analogous to the modification of the recording system of the invention, also in the method of the invention, the data of the digital road map are stored in the memory of the computer unit as vector data. With vector data sets, no information can be lost due to enlargement or reduction of, for example, a map section.

Preferably, also with a modification of the method of the invention, a tolerance range is fixed in which activation an de-activation, respectively, of the recording of a vehicle is effected. This measure ensures that only those vehicles are recorded which actually are within the area to be recorded.

Further advantages result from the subject matter of the sub-claims.

Brief Description of the Drawings

Fig.1 is a principle sketch and shows a section of a digital road map in vector representation with a highway subject to toll and a rest house not subject to toll.

Fig.2 is a principle sketch and shows a section of a digital road map in vector representation with a highway subject to toll and a toll-free country road.

Fig.3 illustrates the mode of operation of a recording system of the invention.

Preferred Embodiment

Fig.1 is a principle sketch and shows a section of a road map in vector representation, as it is stored, for example, also in the memory of a computer unit of a recording system of the invention. Principally, a representation is called a vector representation, if the road map consists of nothing but coordinates which, for illustration, are merely interconnected by lines. The coordinates of the map are stored in look-up tables. Thus, sections of any size can be represented by appropriate coordinate transformation, without losing information by enlargement or reduction, as this would, for example, be the case with a pixel graphic.

A recording system of the invention serves, in particular, to detecting and recording those vehicle which use roads subject to toll. Other applications are, for example, the police observation of certain vehicles. At the same time, such a recording system may serve as theft protection, as the position and the identification of the vehicle is continuously transmitted. Furthermore, such a recording system can, principally, also serve also, for example, for the traffic monitoring and/or traffic control. By evaluating the recorded data, variable speed limit signs can be controlled, in order to prevent traffic jams with high traffic density.

Vehicles of the present embodiment of Fig.1 are equipped with a satellite navigation system (GPS = "Global Positioning System"). The coordinates of the instantaneous position of the vehicle are determined through the satellite navigation system. Such vehicles are able, for example through radio, to continuously transmit the coordinates of their positions to the recording system. In addition to the coordinate signals, the vehicles have, however, also to transmit identification signals, by which the vehicle can be unambiguously identified by the recording system. The recording system has an appropriate receiver and processing device for receiving and processing the coordinate and identification signals. The processing device consists of one or more computers, which may be networked with each other. The digital map material is stored in the memories of the computers, which, among others, is provided by commercial traders. Thus, Fig.1 illustrates quasi a digital image of a map section.

Referring to Fig.1, numeral 10 designates a highway subject to toll, which is illustrated as a winding line. Entrances 12 and 14 lead to the highway 10. Exits 16, 18 lead away from the highway 10. Furthermore, a rest house 20 lies at the highway, to which an exit 22 from the highway 10 leads. A vehicle gets back to the highway from the rest house through an entrance 24. While the highway 10 is an area subject to toll, the rest house is a toll-free area. The highway is subdivided into appropriate sections 26, 28, 30, 32 and 34. The sections 26,28,30,32,34 of the highway 10 are indicated by dashed lines. In these sections 26, 28,30,32, 34, *also called sections*, rectangular segments 36,38,40 and 44 are overlaid over the course of the highway 10.

The rectangular segments 36,38,40,42,44 of each section 26,28,30,32,34 are dimensioned differently both with regard to their lengths and with regard to their widths, this being done in such a way tat they fit appropriately into the sections 26,28,30,32,34. To this end, they are dimensioned with regard to their lengths 46 and widths 48, for each respective section, such that as few as possible rectangular segments 36,38,40,42,44 are used, so that as little memory capacity of the computer is consumed. However, the rectangular segments 36,38,40,42,44 of each section 26,28,30,32,34 are always of the same size.

As with too wide rectangular segments 48 easily areas may be covered which no longer belong to the sections 30 subject to toll –in the present embodiment, for example, the rest

house 20. The rectangular segments 48 have to be dimensioned rather narrow (i.e. small width 48), to prevent the rectangular segments 48 from overlapping also this area. The rectangular segments 26,28,32,34 of other sections can, however, be dimensioned considerably wider.

As soon as the coordinates of a vehicle transmitted to the recording system reach such a rectangular segment 36, 38, 40,42,44, road using fees become de. The toll recording is activated thereby. Not before a rectangular segment 36,38,40,42,44 is left, the toll recording is de-activated. On the basis of the identification signal which is transmitted by the vehicle, the toll for the driven distance on the highway subject to toll can now unambiguously computed for the vehicle.

Fig.2 illustrates a similar situation as Fig.1. The thick winding line is the highway 10 subject to toll. Instead of the rest house 20, a number of country roads 50,52,54 are illustrated as toll-free areas. The country road 50 is located, at least in partial areas, very close to the highway 10. The country roads 52,54 cross the highway 10. The highway 10 subject to toll is subdivided into sections 56,58,60,62. Analogously to Fig.1, each of these sections 56,58,60,62 has individual rectangular segments 64,66,68,70 having appropriate lengths 46 and 48. In the area of section 58, the rectangular segments 66 are very narrow, in order not to overlap the country road 50. The country road 50 namely extends very closely adjacent to the highway 10. Otherwise, toll might be collected for a vehicle which drives along the country road 50. The toll recording is effected in the same way as described above with reference to Fig.1.

As vehicles which drive along the country roads 52 or 54, respectively, necessarily cross the highway 10 subject to toll, toll would have to be collected for these vehicles, as they get into the area of the highway 10 subjected to toll and activate this area though for a short time only. In order to avoid this unjustified toll collection, such vehicles which enter the area subjected to toll at a nearly right angle, are exempt from the recordal. If necessary, also the time of stay within the area subject to toll can be used as a criterion. If a vehicle stays in the area subject to toll for a short time only, it will be exempt from toll recordal.

Referring to Fig.3, the general mode of operation of the recording system of the invention and of the method for the recording of vehicles is to be explained briefly, as already indicated further above. A vehicle 72 receives, from a satellite navigation system, data about to its exact position. Through radio, the vehicle 72 transmits the position coordinates , arrow 78, and an individual identification signal, arrow 80. These position coordinates 78 and the identification signal are received by a receiver device 82 of a recording system 84. In the recording system, it will be determined on the basis of a geographic map in vector representation (as described with reference to Fig.1 and Fig.2) whether toll is due for the instantaneous position of the vehicle 72, box 88. If toll is due, road using fees are allotted to the account of the vehicle which has been identified by the identification signal 80, box 90. Subsequently, automatically an invoice can be sent to the holder of the vehicle, box 92.